PATENT

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For:	DEVICE AND METHOD FOR PROTECTING AN ELECTRIC MACHINE

LETTER

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Sir:

Amended claims are attached hereto (which correspond to Article 34 amendments or to claims attached to the International Preliminary Examination Report), as required by 35 U.S.C. § 371(c)(3). The Article 34 amended claims are incorporated in the included substitute specification and Preliminary Amendment.

Respectfully submitted,

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operating state of the overload relay (CLASS, imbalance, present current value, present limit value, ...) needs to be simulated. The prediction is therefore associated with a very high degree of complexity and can therefore not be carried out in real time. A further disadvantage thus results in that the user needs to simulate the model function in the user program of its controller. For this purpose, corresponding knowhow is required and considerable cycle loads result.

EP 0 999 629 A1 has disclosed an apparatus for the thermal overload protection of an electric motor. In this apparatus, the supply currents to the motor are detected, and, associated with specific supply currents, times are defined at which the current is to be disconnected. In a thermodynamic model, state equations are used whose parameters are determined as a function of these times. A calculation is performed to ascertain whether predetermined threshold values have been exceeded or not.

US patent 6,424,266 B1 describes a device for preventing thermal damage to an electric load transformer. The input current into the load transformer is detected and, on the basis of a prediction algorithm, which uses the current value and the present value for the ambient temperature, a time is calculated after which an output alarm contact is to be closed.

US patent 4,467,260 has disclosed a motor starter controlled by a microprocessor. In this case, a curve is used, inter alia, in which the temperature of a rotor is exponentially dependent on the time.

The object of the present invention is to propose an apparatus and a method for protecting electric machines with which it is possible to predict a temporal trigger reserve without a high degree of complexity.

This object is achieved by a protective apparatus for protecting an electric machine against current overload in accordance with patent claim 1 and a method for protecting an electric machine against current overload in accordance with patent claim 1 and a method for protecting an electric machine against current overload in accordance with patent claim 7.

It is thus possible according to the invention to realize a temporal prediction, together with an evaluation of the dynamic, temporal trigger reserve of an electronic overload function, in a device with overload functionality.

The thermal motor model is calculated in the prediction device as the present thermal variable as a function of the present current value, of a current limit value and of a time which is characteristic of the electric machine, and the thermal motor model is used as the basis for the prediction. The thermal motor model *TMM* is preferably calculated recursively in the prediction device. The present thermal motor model is expediently used for dynamically calculating the time value for the prediction.

The prediction device and/or the utilization device can advantageously be parameterized. Any desired limit values and device properties can thus be prescribed and used in the prediction or utilization.

A disconnection signal or warning signal can be generated as a control signal in the utilization device. The prediction can thus be used to ensure that a desired control cycle with excessive current is not possible at all or that a warning is output when the control cycle is created or used to indicate that the control cycle has not completely run and a premature interruption has taken place.

It is therefore possible according to the invention for the calculation of the prediction of the temporal trigger reserve to be integrated in a device having an overload function. Owing to this integration, it is no longer necessary for the device having the overload function to be capable of communication.

In one specific embodiment, the temporal trigger reserve can be monitored by means of limit-value monitoring devices at a predictor limit value. The temporal trigger reserve and/or the result of the limit-value monitoring device can also be processed locally or passed on to the controller (PLC) for

processing purposes. The predictor limit value and the subsequent response

Patent claims

1. A protective apparatus for protecting an electric machine against current overload, having:

- a current value provision device for the purpose of providing a present current value with which the electric machine is operated,
- a prediction device (2, 4) for the purpose of determining the thermal motor model *TMM* as a function of the present current value, a predetermined current limit value, and a time, which is predetermined by the classification of the electric machine, and for the purpose of predicting an absolute or relative time value for a trigger reserve, in the case of which the thermal motor model reaches a value of one, and
- a utilization device (5) for the purpose of utilizing the time value for the trigger reserve for generating a control signal.

2. The protective apparatus as claimed in claim 1, in which, when providing a current I_{pres} from the point in time $t = 0$ on, *TMM* is given by:

$TMM = \left[1 - e^{\frac{1}{\tau}}\right] \cdot \frac{I_{pres}}{I_{limit}}$, where I_{limit} is the current limit value, and t is the predetermined time.

3. The protective apparatus as claimed in claim 1, it being possible for the thermal motor model to be calculated recursively in the prediction device (2, 4).

4. The protective apparatus as claimed in claim 1 or 3, it being possible for the time value to be calculated dynamically using the present value for the thermal motor model.

5. The protective apparatus as claimed in one of the preceding claims, it being possible for the prediction device (2, 4) and/or the utilization device (5) to be parameterized.

6. The protective apparatus as claimed in one of the preceding claims, it being possible for a disconnection signal or warning signal to be generated as a control signal in the utilization device (5).

7. A method for protecting an electric machine against current overload having the following steps:

- provision of a present current value with which the electric machine is operated,
- determination of the thermal motor model on the basis of the present current value, a predetermined current limit value and a time predetermined by the classification of the electric machine, and
- prediction of an absolute or relative time value for a temporal trigger reserve as a function of the thermal motor model in which the thermal motor model reaches a value of one,
- generation of a control signal using the time value, and
- driving of the electric machine using the control signal.

8. The method as claimed in claim 7, in which, when providing the present current value I_{pres} from the point in time $t = 0$ on, the thermal motor model is given by:

$TMM = \left[1 - e^{\frac{1}{\tau}}\right] \cdot \frac{I_{pres}}{I_{limit}}$, where I_{limit} is the current limit value and t is the predetermined time.

9. The method as claimed in claim 7, in which the thermal motor model is calculated recursively.

10. The method as claimed in claim 7 or 9, in which the time value is calculated dynamically using the present thermal motor model.

11. The method as claimed in one of claims 7 to 10, in which the process for generating a control signal is parameterized individually.

12. The method as claimed in one of claims 7 to 11, a disconnection signal or warning signal being generated as a control signal.